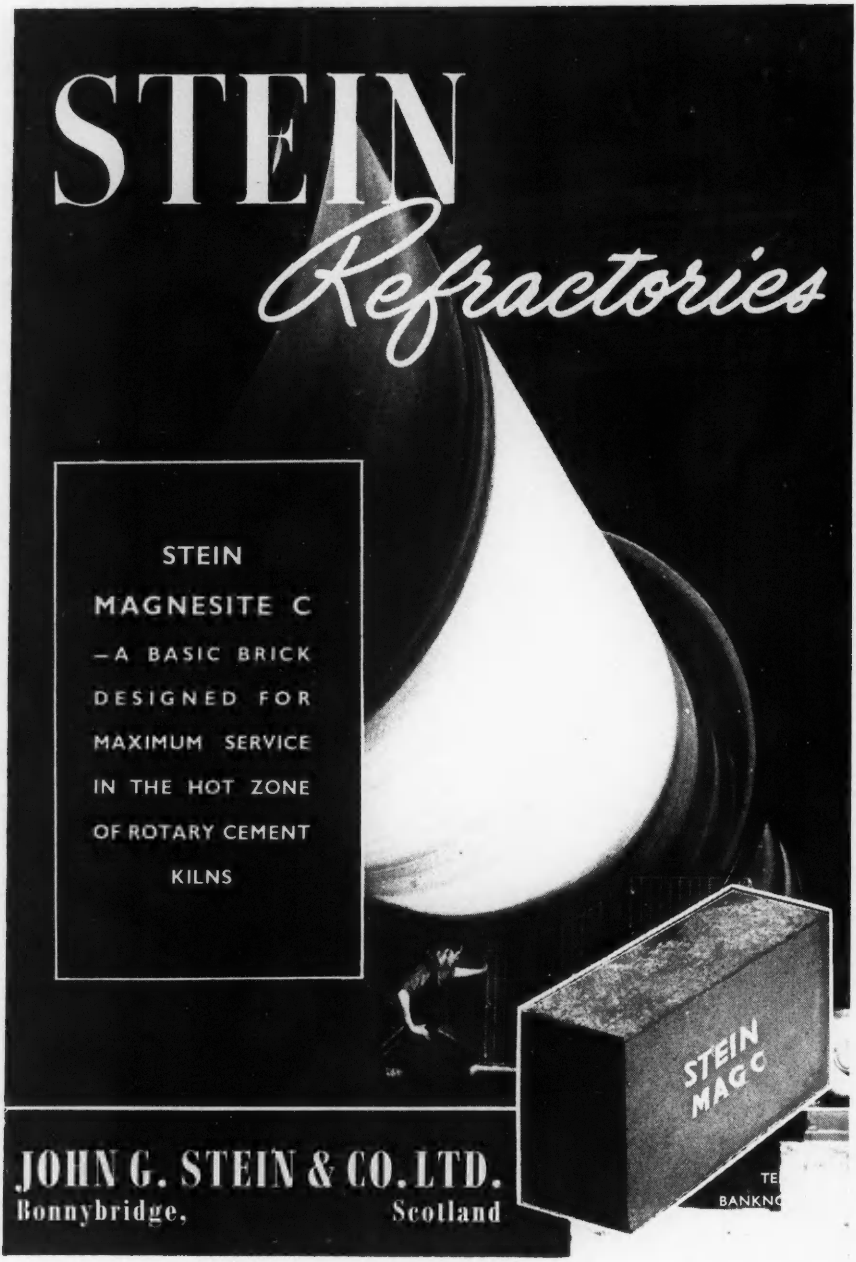
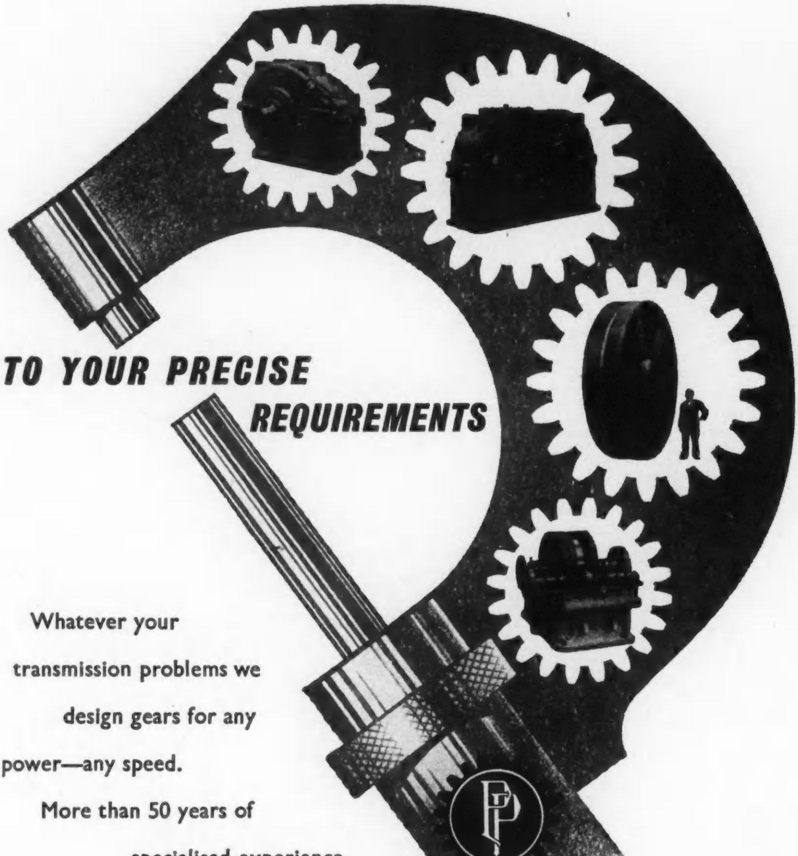
CEMENT AND LIME MANUFACTURE

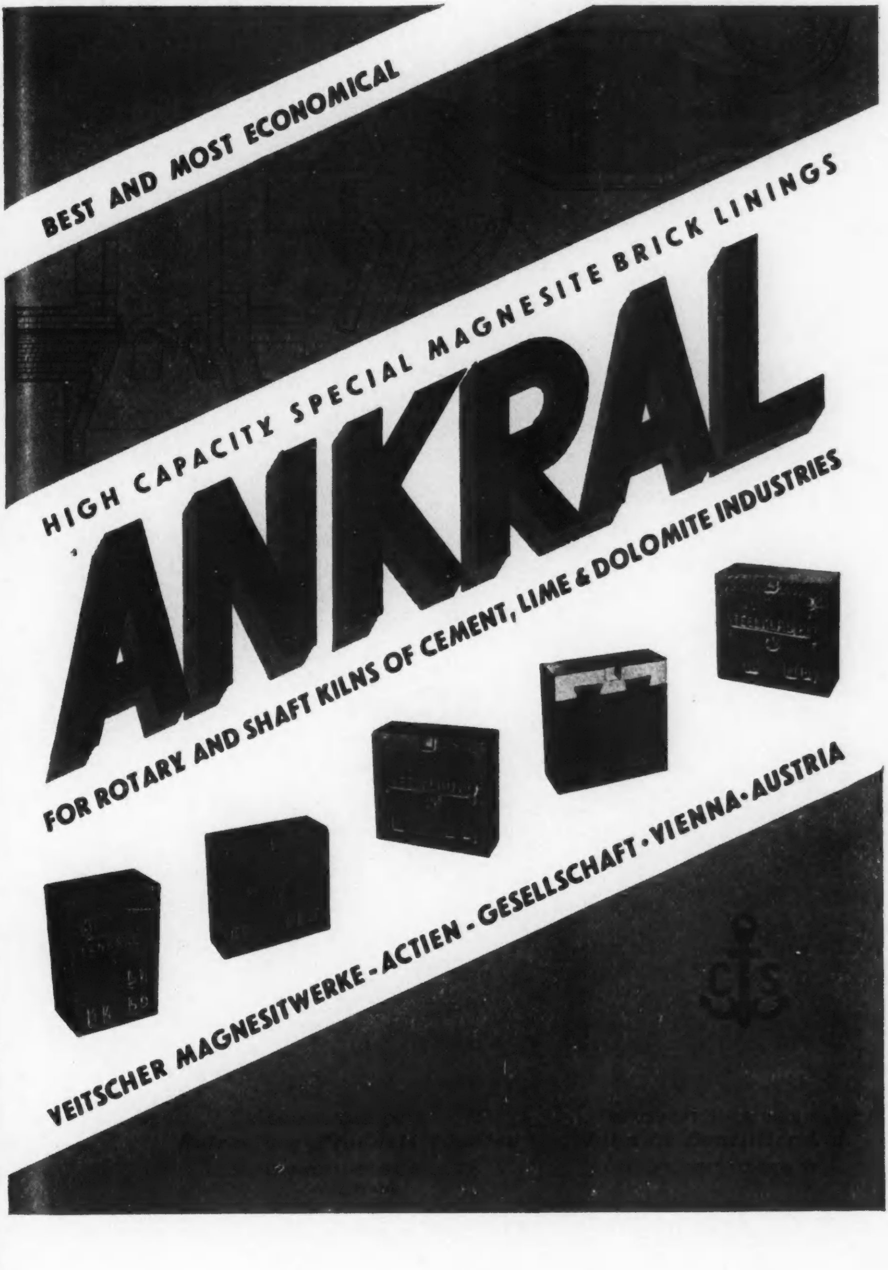
L. XXXI. No. 5 | SEPTEMBER, 1958 | Price 1s. 2d. Annual subscription 7s. ($1.30 in Canada and U.S.A.)

PUBLISHED BY CONCRETE PUBLICATIONS LTD., 14 DARTMOUTH STREET, LONDON, S.W.1


STEIN
Refractories
STEIN
MAGNESITE C
—A BASIC BRICK
DESIGNED FOR
MAXIMUM SERVICE
IN THE HOT ZONE
OF ROTARY CEMENT
KILNS
STEIN
MAG C
JOHN G. STEIN & CO. LTD.
Bonnybridge, Scotland

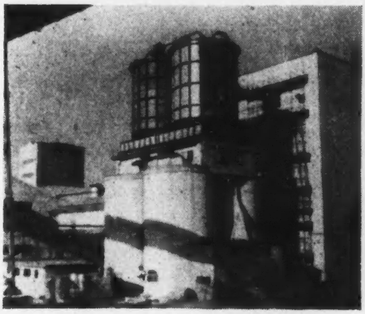
A



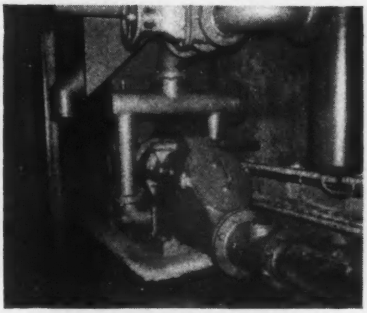

BEST AND MOST ECONOMICAL
HIGH CAPACITY SPECIAL MAGNESITE BRICK LININGS
ANKRAL
FOR ROTARY AND SHAFT KILNS OF CEMENT, LIME & DOLOMITE INDUSTRIES
VEITSCHER MAGNESITWERKE - ACTIEN - GESELLSCHAFT · VIENNA · AUSTRIA

FULLER PLANT

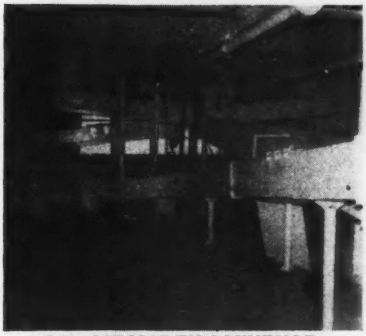
We illustrate some of the Fuller range of plant in use in cement works throughout the world. Other Fuller Plant includes Rotary Gate Valves, Material Level Indicators, Remote Control Plant, etc., full technical information of which will be sent on request.



AIRMERGE BLENDING INSTALLATION
Including Aeration Blending Tanks and Raw Material Storage Silos.



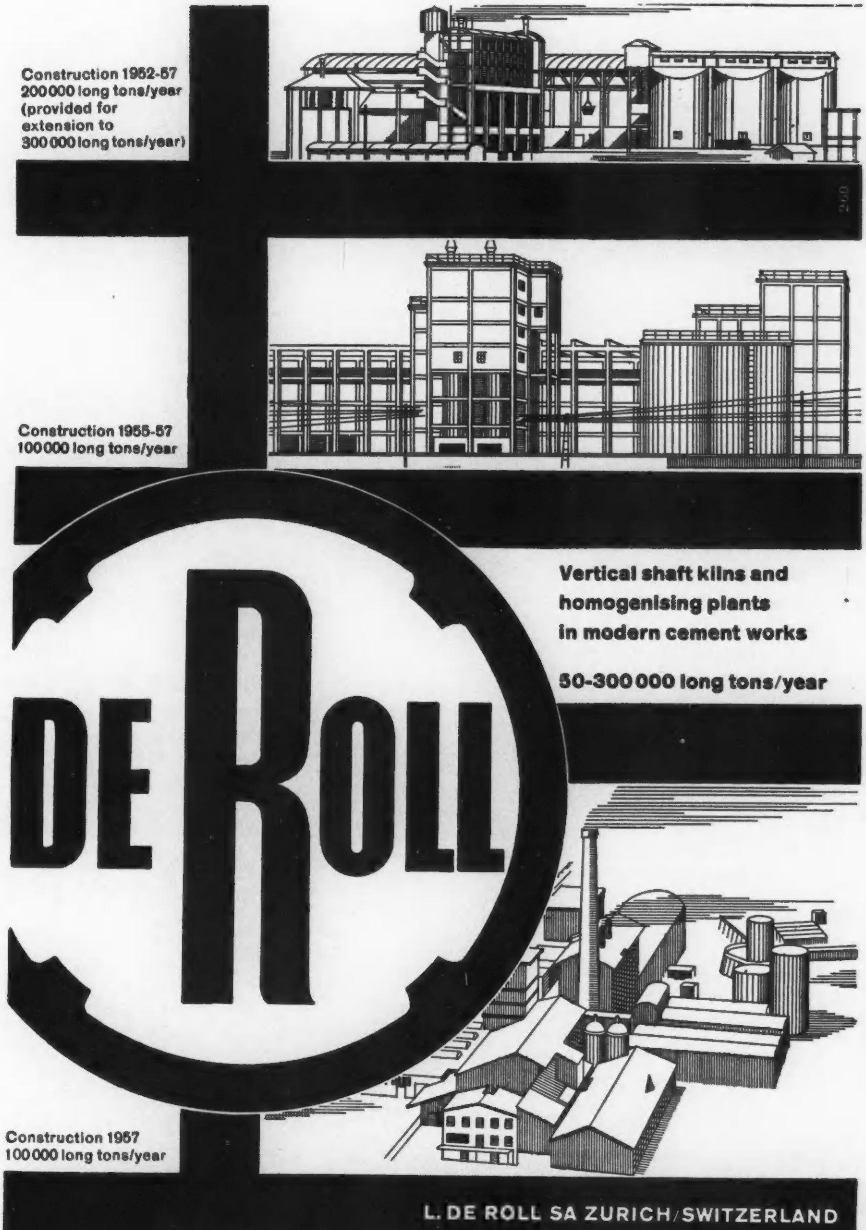
FULLER-KINYON PUMPS
For Pneumatic Conveying of Raw Material and Cement.

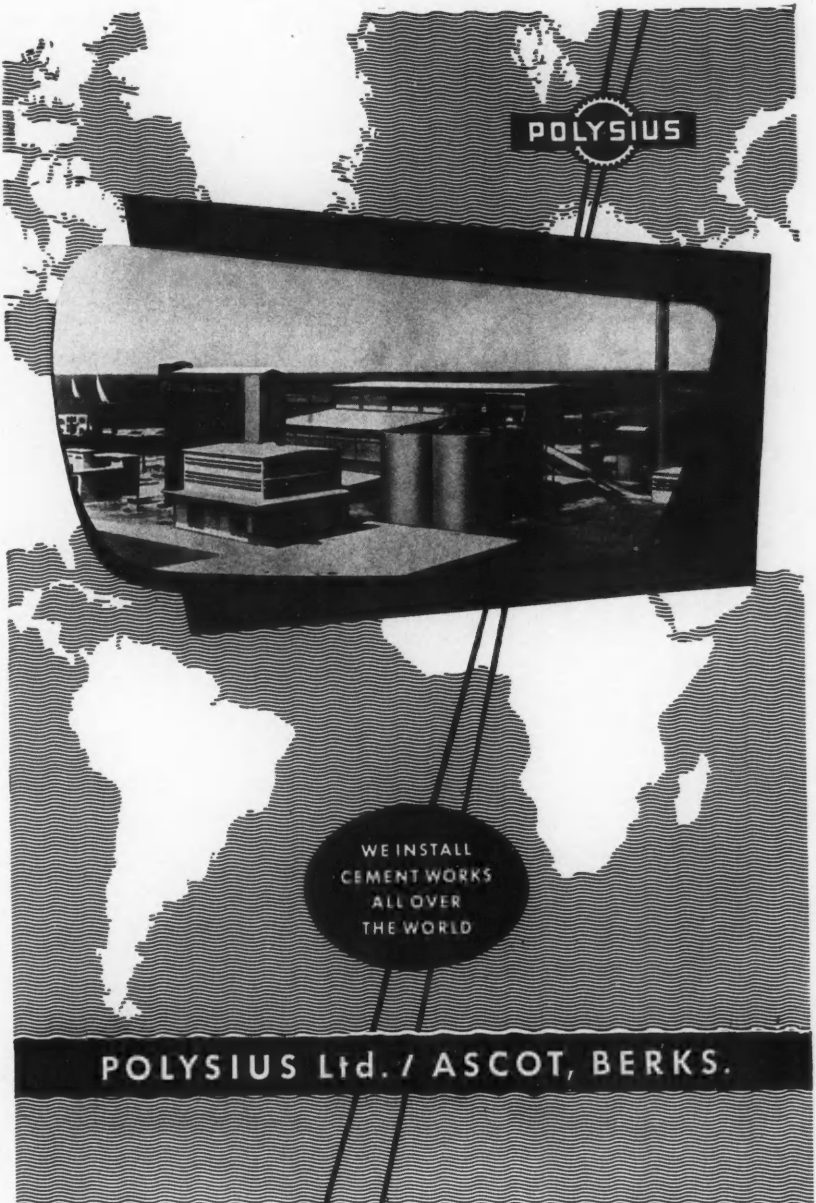


"F.H. AIRSLIDE" CONVEYOR
For Transferring Raw Material from Blending Tanks to Storage Silos.

FULLER INCLINED GRATE COOLER
With Integral Clinker Breaker.

[redacted]


Construction 1952-57
200 000 long tons/year
(provided for
extension to
300 000 long tons/year)
Construction 1955-57
100 000 long tons/year
DE ROLL
Vertical shaft kilns and
homogenising plants
in modern cement works
50-300 000 long tons/year
Construction 1957
100 000 long tons/year
L. DE ROLL SA ZURICH/SWITZERLAND



POLYSIUS
WE INSTALL
CEMENT WORKS
ALL OVER
THE WORLD
POLYSIUS Ltd. / ASCOT, BERKS.

CEMENT AND LIME MANUFACTURE

PUBLISHED ALTERNATE MONTHS. PRICE 1s. 2d. A COPY. ANNUAL SUBSCRIPTION 7s. POST FREE $1.30 IN CANADA AND U.S.A.

PUBLISHED BY
CONCRETE PUBLICATIONS LIMITED
14 DARTMOUTH STREET, LONDON, S.W.1

TELEPHONE: WHITEHALL 4581.
TELEGRAPHIC ADDRESS:
CONCRETIUS, PARL, LONDON.

PUBLISHERS OF
"CONCRETE & CONSTRUCTIONAL ENGINEERING"
"CONCRETE BUILDING & CONCRETE PRODUCTS"
"CEMENT & LIME MANUFACTURE"
"THE CONCRETE YEAR BOOK"
"CONCRETE SERIES" BOOKS.

VOLUME XXXI. NUMBER 5. SEPTEMBER, 1958

Research on Cement.

THE following notes are abstracted from the report of the Building Research Board of the Department of Scientific and Industrial Research for the year 1957. (Published by H.M. Stationery Office at 5*s.* 6*d.*)

Pozzolanic Properties of Pulverised-fuel Ash.

A study is being made of the pozzolanic properties of four varieties of pulverised-fuel ash. The results up to one year indicate that the development of strength in mixtures of pulverised-fuel ash, lime, and sand is poor, and that there is no correlation between removal of free lime from the system and the development of strength. However, when pulverised-fuel ash is used as a 20 per cent. replacement for Portland cement in mortars and concretes, the deficiency in strength at early ages is recovered after about one year. So far the results show that pulverised-fuel ash can be regarded only as a slow-acting pozzolana.

Cement and Silicate Chemistry.

In the last report an account was given of the high-temperature microscope and its use for the direct observation of the behaviour of molten materials at very high temperatures. A second high-temperture microscope at the Station permits observations to be made in special atmospheres and extends the range of observation to over 2,000 deg. C., provision being made for recording the sequence of events by cinemicrography. In the course of an investigation of the effect of phosphate content on cement, this microscope revealed that tricalcium silicate is capable of crystallising directly from the liquid phase in the system $CaO—SiO_2$ over a very narrow range of composition and temperature. Previously it had been supposed that tricalcium silicate, the major constituent of Portland cement, decomposed in the solid state at about 1,900 deg. C. It is now known that decomposition takes place during melting at a temperature of 2,070 deg. C. and that a eutectic is formed between tricalcium silicate and dicalcium silicate at 2,050 deg. C.

Much of the work on liquidus relationships in the system $CaO—SiO_2—P_2O_5$ has been completed. The phase relations in this system at lower temperatures have been clarified by adapting the high temperature microscope to form the basis of a high-temperature X-ray camera, which has been used to obtain diffraction patterns from powdered specimens at temperatures up to 1700 deg. C. and could if necessary be operated at even higher temperatures.

Hydration of Cement.

A mineralogical examination has been made of the setting of supersulphate cements of lower lime content than usual. Four granulated slag samples, very different in physical appearance but similar in chemical composition, have been made into supersulphate cements with varying contents of calcium sulphate and Portland cement, and small-scale strength tests and mineralogical examinations have been carried out on neat cement cubes. The results show that similar strengths are obtainable for similar mixtures for each type of slag irrespective of its original physical appearance, and that the main cementing mineral is of the ettringite type. The composition of this mineral appears to be a solid solution between $3CaO.Al_2O_3.3CaSO_4$ aq. and (probably) $3CaO.Al_2O_3.3Ca(OH)_2$ aq.

In the further study of the system lime-alumina-water, a modification of the tetra-calcium aluminate hydrate, $4CaO.Al_2O_3.19H_2O$, has been obtained which gives the same X-ray basal spacings as that previously reported, but differs somewhat in other spacings. The X-ray pattern of the previous modification tends to change to that of the new one, indicating the greater stability of the latter. The differences may be connected with some disorder of layers in the crystal lattice.

Consolidation of Samples for Testing.

In the last report it was stated that the Dutron shock-vibration table appeared to give better uniformity of compaction than other mechanical methods tested. During the year tests have been made in eight countries, and a preliminary examination of the results has shown that the shock method of compaction gives a satisfactory degree of uniformity.

Compaction of Concrete by Vibration.

The installation of a more powerful experimental vibrator has permitted work to be done on 6-in. and 4-in. cubes. The latter were eventually adopted as the standard to be used, since the larger size restricted the acceleration that could be achieved at the highest frequencies. With both sizes the variation of cube strength with frequency of vibration is similar to that observed before, showing an optimum frequency of vibration for a particular mixture.

Mortars.

Tests on the strength of brickwork built with bricks of medium strength and cement-lime-sand and aerated cement-sand mortars have shown that the aerated cement-sand mixes that have generally been suggested as alternatives to cement-

lime-sand mortars are suitable for normal brickwork. The tests are being extended to include stronger bricks (5,000 and 7,500 lb. per square inch) to obtain data on the use of aerated mortar mixes in brickwork designed for higher stresses.

Comparative rendering trials using cement-lime-sand and corresponding aerated cement-sand mixes are being continued to determine whether the surface crazing that has been observed on panels rendered with aerated mixes, and the deficiencies in resistance to rain noted in tests on some of them, are significant.

Methods of testing mortar plasticisers are being examined with a view to the preparation of a British Standard.

Steam Curing.

During the high-pressure steam curing of concrete the lime set free by the setting of the cement may react with part of the aggregate. A similar reaction is responsible for the hardening of autoclaved products such as lime-pulverised-fuel ash or lime-shale aerated concretes.

A mineralogical study is being made of the nature and extent of such reactions. Mixtures of lime and fine aggregate (passing 200-mesh B.S. sieve) have been hardened at a steam pressure of 160 lb. per square inch and the products examined by X-rays and differential thermal analysis. The aggregates investigated include quartz, pulverised-fuel ash, sintered colliery-shale, and granulated and foamed blastfurnace slags. It has been found that lime reacts with pulverised-fuel ash, shale, or quartz to form the mineral tobermorite; the mineral is in a poorly crystalline state after short autoclaving periods and is better crystallised after longer treatment. In lime-slag mixtures the mineral produced by autoclaving is dicalcium silicate alpha-hydrate. Strength measurements on a few specimens suggest that much higher strengths are to be expected when tobermorite is the cementing mineral.

Cement Production in the Phillipines.

The production of cement in the Phillipines in the year 1957 amounted to 3,000,000 barrels (say, 500,000 tons).

New Cement Works in China.

Construction has started of a cement works, with a capacity of 315,000 tons a year, at Kweiyang, Kweichow Province.

Production of Cement in Switzerland.

The production of cement in Switzerland in the year 1957 amounted to 2,511,339 tons, compared with 2,380,278 tons in 1956. Due to the lower requirements it is expected that production in 1958 will be reduced to about 2,000,000 tons.

The Cement Industry in the U.S.S.R.

THE production of Portland cement in the U.S.S.R. increased from 1,780,000 tons in 1917 to about 29,000,000 in 1957. The Soviet Union is now the second largest producer of Portland cement in the world, following the U.S.A. (54,000,000 tons); the Federal German Republic produces 20,000,000 tons, Japan 13,000,000 tons, and the United Kingdom about 12,800,000 tons. In the year 1917 there were about 49 cement works in Russian territory, with a capacity of about 3,300,000 tons a year. In most of these shaft kilns were used, with little labour-saving machinery, and most of the plant suffered from the lack of maintenance and from war damage. In 1920 only about 33 works were still in operation, and the total output had fallen to less than 1,000,000 tons a year. The State Planning and Cement Research Institute (Giprotsement) was established in 1937 to develop the design of new plant and improve the quality of the cement. The works at Gruzinsk, Sukhodolsk, Kuvasaisk, and Spartak are among those constructed under the Institute's supervision.

In recent years two standard types of rotary kiln have been developed: one has diameters of 11 ft. 9 in., 10 ft. 9 in., and 11 ft. 9 in. and a length of 490 ft., with an output of 20·8 tons of clinker per hour; the other has diameters of 9 ft. 10 in., 8 ft. 10 in., and 9 ft. 10 in., is 415 ft. long, and has an output of 12½ tons of clinker per hour. A chain cooling system is used at the exit end of the kilns (the gas temperature at the exit is less than 200 deg. C.) and the heat required for burning the clinker is about 1,600 kg. calories per kilogram of clinker. All transport operations are mechanical, and multiple-stage raw-meal grinding is provided. Experience gained since these kilns were installed shows that the output of clinker can safely be increased to between 23 and 25 tons per hour for the larger kilns and to 13 tons per hour for the smaller.

Eighteen new works were constructed between 1945 and 1947; in 1957 these works accounted for 35 per cent. of the total output. Most of these works are equipped with rotary kilns of the types described in the foregoing. Twelve smaller works were also constructed during the post-war period, their total output in 1957 being about 1,500,000 tons.

The average distance over which cement must be transported between the works and the site has been reduced from 550 miles in 1950 to less than 350 miles. However, longer distances are still necessary in some areas, such as Siberia (about 700 miles).

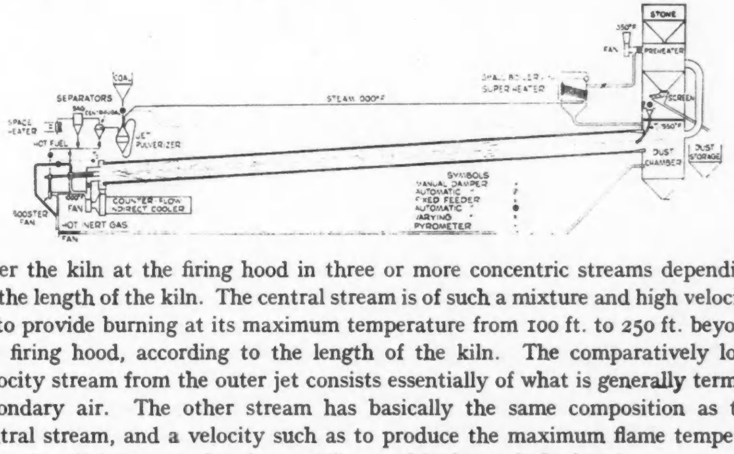
Most of the cement manufactured in the U.S.S.R. complies with the requirements of the respective standard specifications, which are in most cases similar to European specifications. Apart from ordinary Portland cement, rapid-hardening, and low-heat Portland cements, there are specifications for white Portland cement, blastfurnace slag cement, blastfurnace pozzolana cement, blastfurnace alumina cement, slag-lime cement, anhydrite cement, Roman cement, Portland-magnesia and slag-magnesia cements, and oil-well cement. In addition, hydrophobic cement, expansive cement, and self-stressing cement are made.

Proposed New Type of Rotary Kiln.

A NEW type of kiln, designed by Mr. Theron C. Taylor, and which is the subject of U.S.A. patent No. 2,624,562, is described and discussed in an article (of which the following is an abstract) in "Pit and Quarry" for May, 1958.

The capacity and thermal efficiency of a short rotary kiln can be increased by heating the stone or slurry before it enters the kiln. In the case of high-calcium lime the greatest advantage results when the kiln is used exclusively for calcination, with gases exhausted at 1,500 to 1,600 deg. F. and the stone entering from a separate heater at a temperature of 1,450 to 1,550 deg. F. In a long kiln it is necessary to have a long flame of fairly uniform intensity. In the proposed new kiln this is produced by a burner consisting of multiple concentric jets of different velocities, combined with the recirculation—with the least loss in temperature—of a portion of the inert gases from the dust chamber, plus an unusually high preheating (900 to 1,100 deg. F.) of the combustion air and fuel.

The burner is entirely outside the kiln. Fuel, hot air, and hot inert gases



enter the kiln at the firing hood in three or more concentric streams depending on the length of the kiln. The central stream is of such a mixture and high velocity as to provide burning at its maximum temperature from 100 ft. to 250 ft. beyond the firing hood, according to the length of the kiln. The comparatively low-velocity stream from the outer jet consists essentially of what is generally termed secondary air. The other stream has basically the same composition as the central stream, and a velocity such as to produce the maximum flame temperature at a distance varying from 12 ft. to 16 ft. beyond the hood.

In normal operation, preheated stone or slurry is delivered to the kiln at a constant weight depending upon the speed of rotation of the kiln, which is twice or more the usual kiln speeds. The temperatures of the preheated stone or slurry, the combusion air, and the fuel are practically constant. A thermal element, which is placed in the dust-chamber so that the temperature at this point does not vary more than 5 deg. F., automatically controls the quantities of fuel and combustion air within 5 per cent.

To dispense with all manual controls while the kiln is working the control of the degree of burning must be stable. A radiation pyrometer is focused on the finished product at a point about 14 ft. from the firing hood and alters only within

5 per cent. the quantity of hot inert gases which produce maximum flame temperature at about 14 ft. from the firing hood. A fall of a few degrees from the desired temperature at which calcination is essentially completed indicates a trace of unburned core, and calls for a slight reduction in the supply of inert gas to that stream. This slight reduction produces three results: (1) the maximum temperature of the flame contacting the product rises slightly; (2) the velocity of the stream decreases slightly; and (3) combustion starts sooner, causing the hot-test zone of this stream to move closer to the burner, thus slightly prolonging exposure of the product to increased heat and converting the trace of core to lime.

Conversely, in lime manufacture, if the temperature of the product rises a few degrees the radiation provides for an increase in the amount of inert gas before the surface of the product can be overburned. In this case the maximum flame temperature falls slightly, the velocity of the stream increases, and the flame is lengthened. There is no need for further adjustment even during a transition from summer to winter conditions.

The combustion system and controls described are designed to eliminate the formation of slag rings and to remove many of the causes that require a kiln to be stopped for repairs. The system also provides a means of preheating the combustion air and fuel, a choice of several types of preheaters, and a form of indirect heat exchange for cooling the product and heating the combustion air. It is claimed that this system enables the production of 1,000 or more tons per day of any kind of lime or cement in one rotary kiln with a fuel consumption no higher than that now required to produce 400 tons per day.

The Cement Industry in Pakistan.

The Pakistan Industrial Development Corporation is to build a cement factory at Chittagong with an annual capacity of 150,000 tons. A fourth kiln is to be added to the Corporation's Zeal Pak cement factory at Hyderabad. The Corporation has invited tenders for the installation of a wet-process cement works with a capacity of 1000 tons a day at Begmanji near Rohri.

Production of Cement in Syria.

It is reported that 629,000 tons of cement were produced in Syria in the year 1957, compared with 651,000 tons in the previous year. The Aleppo Cement Company is considering the erection of a cement works at Latakia, in addition to the works now in course of construction at Aleppo and Homs and a proposed new works at Hama.

Deviations from the Equilibrium State in Cement Clinker.

THE following is an abstract of an article by H. Kramer, in "Zement-Kalk-Gips" for August 1957, in which it is shown that the calculated equilibrium composition of cement clinker is seldom if ever completely attained in practice.

Inequalities depending on the type and method of preparing the raw materials, as well as differences in the burning and cooling processes, leave traces which are discernible under the microscope and which can be used as indications of the history of any given clinker.

For the purpose of discussion, equilibrium in clinker is defined as the composition according to Mr. Bogue's formula, regarding the sintered mass as if it had crystallised out of a melt at a high temperature. The resulting equilibrium, which is strictly speaking unstable at ordinary temperatures, is frozen by cooling. In the ideal state the resulting minerals should be evenly distributed, but this state is approached only in the fused portions of the clinker, and normal commercial clinker shows innumerable zones enriched by individual components. The origin of these zones can be traced to many causes. The reactions forming the minerals occur in a system of which only one-third is liquid. The liquid acts as a transporter of the partners in a reaction, so that the velocity of the reaction depends on the size and distribution of the partners, on the amount and type of the liquid phase, and on the velocity of diffusion.

The maximum size of a grain which will react completely with a given partner, under given conditions of liquid phase and diffusion, varies according to its nature. However, the assumption that amorphous silica (flint or opal) reacts more readily than crystalline silica (from sand or quartzite) is now disproved; when they are equally finely divided, their reactivity is similar. Grains of limestone or quartz of diameter less than 0·1 mm. are usually completely absorbed. With larger grains, limestone produces inclusions of free lime, and quartz produces clusters of C_2S. These inclusions of lime are distinctly different from free lime (occurring with finely-divided raw materials) when a uniform overall excess exists or when zones rich in lime are caused by clusters of C_2S elsewhere or irregularities in the ground mass. Free lime from a grain tends to remain associated with the location of the nucleus of the former grain, but quartz frequently moves from its original position leaving a pore fringed with C_2S.

A porous mixture tends to retard ionic contact and exchange in the sintering stage, leading to regions of C_3S with residual lime and other regions containing pockets of C_2S. Arrested reaction can be observed in the case of a relict pore of a grain of lime. This is surrounded by a zone of C_2S arising either from shrinkage of the grain of lime, from inflation by carbon dioxide gas, or from retraction of the rest of the clinker. The lime has thus become excluded from further participation in the reaction.

A typical relict of a grain of quartz in the form of a nest of C_2S is surrounded by

a zone which is greatly enriched in lime and which consists of numerous small crystals of C_3S. Outside this, where there is a lower concentration of lime for the formation of nuclei, the crystals of C_3S are larger and more developed. Crystals are smaller when the proportion of the molten phase is greater, since crystallisation is delayed and finally occurs more rapidly. Crystals of C_3S often show growth striations and zonal development, and inclusions are common especially with clinkers rich in magnesia. A high proportion of Fe_2O_3 in the ground mass tends to promote the growth of crystals of C_3S. When the alumina modulus is about 0·64, very regularly developed crystals of C_3S occur mainly in almost ideally regular distribution. If the alumina modulus is below 0·6, irregular crystals of C_3S occur; these crystals form shapes described as being like "amoebæ" or "atolls", and they are very rich in inclusions. If the clinker is rich in alumina the crystals of C_3S are small and irregularly formed, just as when the lime concentration is high.

The interstitial mass which separates from the molten phase is dependent on the composition of the melt as well as on the rate of cooling. In normal clinker the aluminate phase separates first and the gaps are subsequently filled by ferrite phase, but if the alumina modulus exceeds 1·06 the sequence of separation is reversed.

Coal-ash causes little non-homogeneity if the raw material is porous so that the fused ash can penetrate easily. If the ash remains on the surface of a granule a crust with a low lime content is formed; this crust then contains C_2S and aluminate and ferrite phases distinguishable from the rest of the clinker. Since the calculation of total lime content takes the ash into account, the low lime content of the crust results in high lime content elsewhere. The crust is more easily fusible than the rest of the clinker and is therefore "sticky." If by movement this comes into contact with a mixture rich in lime many zonal variations occur in the crust, such as an external layer rich in C_3S covering a layer rich in C_2S, with finally an interior rich in C_3S. In some cases the ash enters into an unaggregated flour, and then becomes completely absorbed by intimate mixing, but sometimes it remains in the ground mass covered with raw material. The raw material itself can become granulated and encased in a layer of more raw material, so that on drying a vacant space develops and this acts as a thermal barrier delaying decarbonisation, sintering, and the attainment of equilibrium in the centre.

Apart from all these variations attributable to the raw material and its preparation and to the burning process, further changes can occur during cooling. The theoretical transformation of C_3S into C_2S and lime fortunately proceeds slowly when foreign ions are present. The rate of cooling affects the transformation of C_2S. With rapid cooling the rounded crystals show fissures but little twinning. Slower cooling causes greater twinning. The important practical consideration is to avoid formation of the unhydraulic γ-C_2S. The ground mass shows distinct differences according to the rate of cooling. With rapid cooling there is practically no separation into components, and the appearance is uniform with only a few incipient dendrites. With medium rates of cooling separation occurs giving an

almost eutectic form, in which an irregularly-developed but evenly-distributed aluminate phase occurs. Slow cooling results in distinct surfaces of demarcation between separate aluminate and ferrite phases. Whether the form of the aluminate phase is cubic or prismatic is not a typical cooling effect, but is associated with other factors such as alkali content.

Concrete Cubes for Testing Cement.

In this journal for May last it was correctly stated that British Standard No. 12, 1958, is the first standard in the world to permit the testing of cement by means of concrete cubes made with non-standardised aggregates. The use of concrete cubes with standard aggregates for this purpose, however, is not new; such a test was included in the tentative Palestine Standard issued in May 1947, and is incorporated in the Standard for Portland Cement issued in June 1951 by the Standards Institution of Israel.

This standard requires that cubes made with ordinary Portland cement and standard aggregates shall have strengths of at least 1,420 lb. per square inch at three days and 2.200 lb. per square inch at seven days. In the case of rapid-hardening Portland cement the corresponding strengths are 1,420 lb. per square inch at one day and 2,630 lb. per square inch at three days.

Details of the standard aggregates are given in *Table I*. The size of the cubes is 120 mm. (about 4¾ in.), and the quantities of materials required for six cubes are 3,110 grammes of cement, 4,240 g. of Naharia sand, 4,240 g. of Haderah sand, 12,720 g. of Binyamina stone, and 1,930 g. of water. The cement and sand are mixed dry until a uniform colour is obtained. The stone is then added and the materials again mixed; finally the water is added and the concrete is mixed by hand for a period not exceeding two minutes until a uniform mixture is obtained.

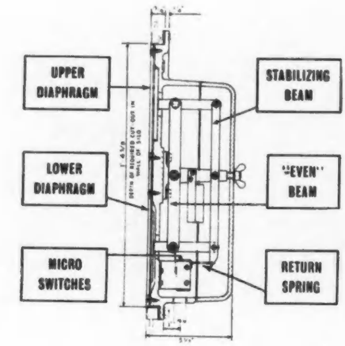
Table I.—DETAILS OF STANDARD AGGREGATES

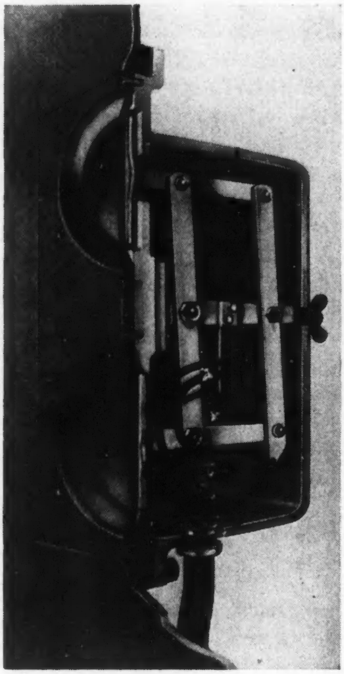
Material	Source	Passing sieve	Retained on sieve	Proportion per cent.
Fine sand	Naharia shore	No. 52 (0·3 mm.)	No. 100 (0·15 mm.)	10
Fine sand	Naharia shore	No. 25 (0·6 mm.)	No. 52 (0·3 mm.)	10
Coarse sand	Haderah shore	No. 14 (1·2 mm.)	No. 25 (0·6 mm.)	10
Coarse sand	Haderah shore	No. 7 (2·4 mm.)	No. 14 (1·2 mm.)	10
Crushed stone	Binyamina Quarry	¾ in.	⅜ in.	30
Crushed stone	Binyamina Quarry	1 in.	¾ in.	30
			TOTAL	100

A Level-indicator for Silos.

THE level-indicator shown in the illustrations has been developed for controlling the level of liquids, powders, granular, and flaked materials. It is unaffected by the air pressure within a silo, and is suitable for high-level and low-level control.

The apparatus comprises two diaphragms arranged one above the other and coupled by a spring-loaded "even" beam which is connected to micro-





switches. Two micro-switches are supplied as standard and they can be arranged to maintain automatically a predetermined level of material within a silo or, alternatively, to actuate audible or visible warning systems. As the material within a silo rises and covers the lower diaphragm, its weight deflects the diaphragm which rocks the beam and operates one or more micro-switches. Conversely, as the level of the material falls and weight is removed from the lower diaphragm, the spring-loaded beam resumes its original position and closes the switch. For extreme conditions, such as high temperatures or when unusual materials are handled, special diaphragms are supplied. The indicator is supplied by Blaw Knox, Ltd.

Automatic Control of a Kiln.

IT is stated that after five months of continuous operation a system of automatically controlling a cement kiln was working well at the works of the Calaveras Cement Co. at San Andreas, U.S.A. The installation is described by Mr. M. C. Sutton and Mr. Lewis A. Parsons (chief chemist and consulting engineer of the Company) in an article in " Rock Products " for June 1958, from which the following is abstracted.

In 1948 a kiln was equipped with an instrument which continuously recorded the oxygen and combustible material in the gases leaving the kiln; this information was recorded on charts. In 1952 the speed of the draught-fan of another kiln was controlled by the oxygen recorder-controller. The resulting constant oxygen and excess air content in the combustion gases led to greater fuel economy.

The next advance was in 1956 when, with changes of the fuel setting by the operator, the speed of the fan responded immediately and proportionally to maintain the predetermined ratio of fuel to air. An almost linear relationship was found to exist between the flow of fuel and the speed of the fan required to produce the required amount of combustion air. This relationship was utilised by feeding the signal from the fuel-flow measuring orifice through a converter (which changed the square-root signal to a linear signal) to a ratio-relay whose output signal set the fan-speed controller. This linear relationship changed slowly with changing resistance in the kiln and cooler, so that the oxygen-controller changed the basic ratio in the ratio-relay to maintain a constant oxygen content in the exit gases. The speed of the fan was controlled by pneumatically setting the speed rheostat in the control of the electric-magnetic clutch.

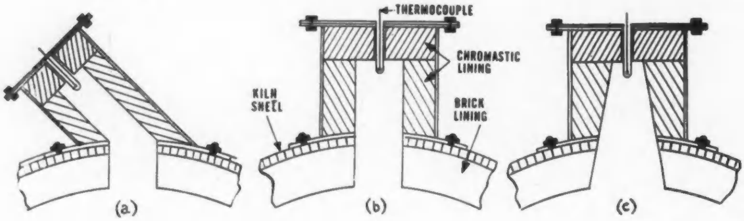
Normally the burner has no way of knowing how heat transfer is progressing until he can see the product, which is usually 50 ft. to 60 ft. from the firing end of the kiln. When the mixture has not been properly heated and calcined, it is usually too late to make drastic fuel adjustments; such adjustments may throw the kiln off balance for several hours, reducing fuel economy and possibly making inferior clinker. Further, most of the CO_2 in the limestone is not driven off before it reaches the burning zone, and no increase of temperature at that point can prevent the clinker from having excess free lime. The burner cannot know if adequate heat transfer is taking place at the centre of the kiln, but can estimate the conditions only indirectly by the temperatures at each end of the kiln; he therefore maintains high exhaust temperatures.

It was decided to install thermocouples in the kiln at this point in order to make possible more gradual fuel changes. This presented several problems. If the thermocouple were projected through the brick lining it would record a fluctuating temperature between that of the gases and that of the mixture; also it would be mechanically weak. If it were embedded in the brick the lag would be great and results erratic, with the additional complication of indicating rising temperatures as the brick eroded.

The kiln concerned is 360 ft. long, 11 ft. 3 in. outside diameter, and 10 ft. 3 in.

diameter inside the brick lining. It is a wet-process kiln, and the chain system occupies about 44 ft. of its length. The kiln rotates at about $1\frac{1}{4}$ revolutions per minute, and has a slope of $\frac{7}{16}$ in. per ft. which gives a material retention time of about two hours. The fuel is natural gas. The mixture has a calculated depth of 11 in. to 15 in. at the bottom of the kiln, and makes contact with 68 deg. to 80 deg. of the circumference. A thermocouple protruding through the brick would therefore be in contact with the material only 22 per cent. of the time, and in contact with combustion gases at a much greater temperature during the rest of the time.

An inclined well (*Fig.* 1a) was first used to retain the material in contact with the thermocouple for as long a period as possible. This prolonged contact was found to be unnecessary since the thermocouple remained at the same temperature even when the well had no solid material in it. During the upper part of the rotation there was no flow of hot gases past the thermocouple, and the heat of the gases which replaced the solid material was not great enough to change the temperature of the thermocouple. A shallower well (*Fig.* 1b) was then installed normal to the kiln. While it recorded temperatures of the mixture satisfactorily so long as it



emptied freely, it had a tendency to plug. This led to the development of the third type of well (*Fig.* 1c) which is satisfactory in every way.

At the beginning of the experiments it was thought that to obtain a continuous temperature record it would be necessary for the thermocouple to be immersed in solid material continuously. Accordingly, three wells were spaced 120 deg. apart around the kiln, with split collecting rings to record the temperature progressively from each thermocouple. This was found to be unnecessary, and now only one well is used about 170 ft. from the firing end. A chromel-alumel thermocouple with a stainless steel protector tube is used, because the recorded temperature averages 1400 deg. F.

The thermocouple is connected to two phosphor-bronze collecting rings mounted around the kiln on insulating blocks, with springs to compensate for thermal expansion. The original three insulated segments are now electrically connected to provide a continuous record with one thermocouple. The electro-motive force of the thermocouple is received from the rings by means of brushes supported in carriers on the rings.

The signal from the thermocouple is received by a temperature recorder-

fans for heavy duties

APPLICATION: induced draught for rotary cement kiln.
TYPE: 'Tornado' 100" dia. HIGH EFFICIENCY blower with heavy pattern casing and impeller.
DUTY: 110,000 c. ft. of gases per min. at 440°F. against 7.35" twg.

Regardless of size — no matter what type—if it's a fan for use in the Cement Industry contact Keith Blackman.

Fans for KILN DRAUGHT
SECONDARY AIR
CLINKER COOLING
DUST REMOVAL
KILN COAL FIRING
SACK CLEANING
CONVEYING
BOILER DRAUGHT
VENTILATING

Write for the fully illustrated Booklet No. 25/31

Keith Blackman Ltd

MILL MEAD ROAD LONDON N17

T.A.7224 607.

Plants for making:

ASBESTOS CEMENT PRESSURE PIPES

ASBESTOS CEMENT SHEETS

WHITE CEMENT

SLAG CEMENT

ASBESTOS CEMENT ENGINEERING CO.

P.O. BOX 34.649 Haupstrasse 26, VADUZ LIECHTENSTEIN, SWITZERLAND

controller (pneumatic control with automatic reset) in the control panel. The signal from the controller passes through a relay to limit high and low fuel settings and then to an indicating flow-controller (pneumatic control with proportional and automatic reset) which controls the fuel-valve to maintain constant temperature of the material at the thermocouple. The supply of fuel and primary air is recorded and the ratio of the primary air to fuel is controlled by a ratio-receiver recorder-controller with a proportional and automatic setting device. The ratio of secondary air is maintained by changes in the speed of the fan and regulated by the oxygen recorder-controller.

Any change in the optimum temperature at the control point, which is about 110 ft. from the beginning of the burning zone, causes an immediate response in the flow of fuel and a proportional change in the primary and secondary air. This response is much faster than is possible by a burner, particularly when he is trying to estimate conditions in the centre of the kiln from the temperatures at the firing and exhaust ends.

MISCELLANEOUS ADVERTISEMENTS.

SCALE OF CHARGES

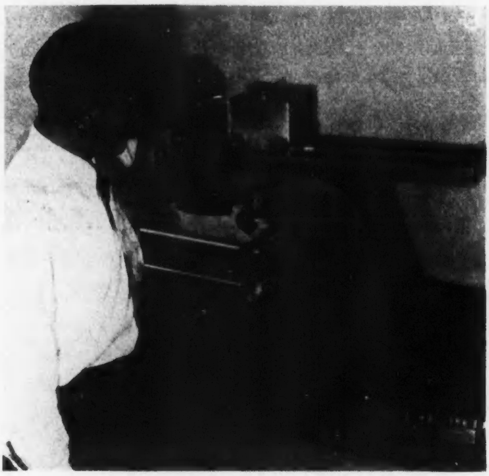
Situations Wanted, 3d. a word; minimum 7s. 6d. Situations Vacant, 4d. a word; minimum 10s. Box number 1s. extra. Other miscellaneous advertisements, 4d. a word; 10s. minimum. **Advertisements must reach this office by the 5th of the month of publication.**

SITUATIONS VACANT

New Tensile Testing Machine.

The machine for testing cement briquettes shown in the accompanying illustration was exhibited at the annual meeting of the American Society for Testing Materials.

The machine is of the beam-loading type, and has a capacity of 1000 lb. The beam is mounted on knife-edges, and a travelling weight moves along the beam and applies the load to the specimen held in the grips. When the specimen fails the beam falls and the drive stops automatically, the load pointer, attached to the travelling weight, maintaining its position on the beam so that the load at failure

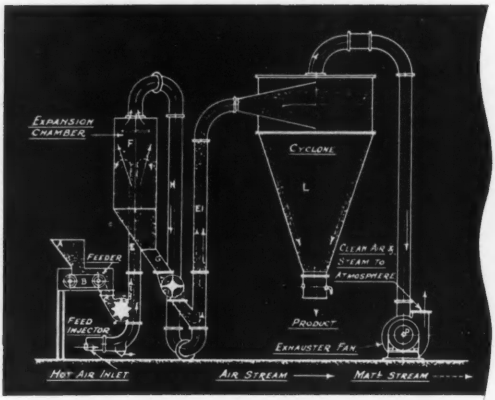


may be read on the scale. The minimum reading on the scale is 5 lb., and any load can be estimated to 1 lb. The machine is claimed to be accurate within 1 per cent. of the load indicated on the scale.

The base of the apparatus measures 9¾ in. wide by 16 in. long, and the overall length including the beam is 28 in.; the height is 23½ in. The frame and loading beam are of steel. The motor drive has a variable speed device so that the load can be applied at slower or faster rates as required. The machine is supplied by Soiltest, Inc., of Chicago, U.S.A.

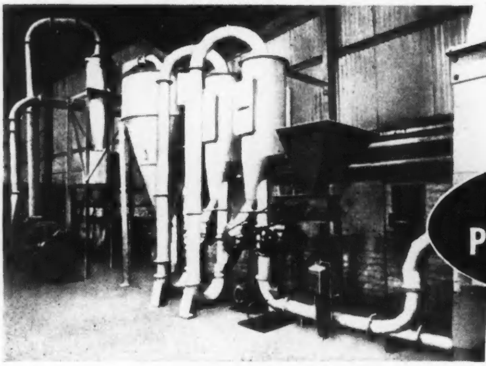
Production of Cement in Formosa.

It is reported that the capacity of the cement industry in Formosa is now 980,000 tons a year and the consumption about 800,000 tons. Attempts are being made to export the surplus. The Asia Cement Corporation is to be granted a loan of 2,500,000 U.S. dollars, presumably for the erection of further cement works.



it's all done by hot air

For drying small coals the British Rema Pneumatic Dryer is quick and effective, and takes up relatively little space. At all times during the drying the particles are separated and swept by high-velocity hot gases; this gives an extremely rapid transfer of moisture from material to the air stream—drying takes place in less than one minute and the material never has time to get too hot. This system of pneumatic drying is also very suitable for materials which are easily damaged by breakage or over-heating—flaked materials, crystalline products, sawdust, etc. Sizes: from ½ ton to 20 tons per hour.



BRITISH 'REMA' PNEUMATIC DRYER

BR26 CLM

To BRITISH 'REMA MANUFACTURING CO. LTD., ONE INDUSTRY ROAD, SHEFFIELD, 9.

Please post "Drying Equipment" to

Name ....

Position ....

Firm ....

Address ....

BRITISH 'REMA' MANUFACTURING CO. LTD.
PROPRIETORS: EDGAR ALLEN & CO. LIMITED
ONE INDUSTRY ROAD · SHEFFIELD 9

Published by CONCRETE PUBLICATIONS, LTD., 14, Dartmouth Street, London, S.W.1, England.
Printed in Great Britain by CORNWALL PRESS LTD., 1-6, Paris Garden, Stamford Street, London, S.E.1.